Corrugated Pipe with Magnetic Targets Inclinometer Settlement System Installation Manual

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REVISION HISTORY

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

The Corrugated Pipe with Magnetic Targets Inclinometer Settlement System a simple, reliable system designed to monitor settlement or heave in rock, soil and different types of man-made structures. The system consists of a one-piece corrugated pipe, corrugated pipe end cap weight, inclinometer casing, target magnets, probe and readout unit.

Corrugated pipe is installed around the outside of the inclinometer casing. Magnetic Targets are positioned around the corrugated pipe. The annular space between the borehole wall and the corrugated pipe is backfilled with soft grout, coupling the pipe to the surrounding ground, so that the corrugated pipe and rings move with settlement or heave.

The probe is a normally open, simple reed switch that closes upon entering the magnetic field of the target anchor. Operation is analogous to a water level meter in that when the switch closes the electrical circuit is completed, causing a buzzer/light in the readout to operate. A two-conductor tape serves to both lower the probe and connect the probe to the circuit board. The switch closes upon entering magnetic field, the signal amplified, and fed to the light/buzzer. Anchor elevation is then read directly from the tape.

The probe incorporates two reed switches to avoid difficulty in manufacturing a ring magnet with uniform polarity, preclude false closure when passing through the three magnetic fields of the magnet, and negate the end effects on the magnetic field when spring steel spider magnets are employed.

Magnets are arranged within the target to yield a uniform, axial magnetic field with a well-defined null zone. Ceramic magnets, rather than ferrous magnets, are used because of their consistent magnetic properties:

- There is no significant change in field strength with time.
- The magnets are unaffected by most groundwater regimes.
- There is no appreciable difference in field strength with temperature.
- Field strength is unaffected by impact.

Like an inclinometer installation, Corrugated Pipe with Magnetic Targets Inclinometer Settlement System utilizes the bottom of the borehole as a reference datum. Typically, the borehole is drilled to stable ground and a datum reference magnet installed. If site conditions preclude the use of the bottom of the borehole as a datum, optical survey methods must be used at the borehole collar.

Settlement or heave is determined by comparing subsequent readings to the initial datum readings.

1.1 TARGET MAGNETS

The targets are magnetic rings applicable to various settlement systems.

FIGURE 1-1 COMPONENTS OF A TARGET MAGNET

The target magnets (Figure 1-1) are pre-installed to the corrugated pipe at specific intervals. However, they can be adjusted to customer intervals in the field. Simply loosen the set screws on the target magnets, move the magnets to the desired location, and tighten the set screws. The deepest target magnetic ring should be at least 300mm (12 inches) from the bottom of the corrugated pipe to allow the reed switch probe to pass the magnetic field.

1.2 ACCESS PIPES

The access pipes include the corrugated pipe and the inclinometer casing.

The one-piece corrugated pipe is used in a wet borehole to protect the inclinometer casing and to ensure the inclinometer casing is free of grout when bonding the corrugated pipe to the borehole. The inclinometer casing is used to monitor both settlement and lateral deformation.

The RST Inclinometer Casing is precision manufactured in 70mm (2.75”) OD and 85mm (3.34”) OD sizes, The RST Glue & Snap casing utilizes ABS cement to join segments, while the RST Snap Seal Coupling System proves an O-ring sealed, self-coupling method.

1.3 TYPICAL APPLICATIONS

Typical applications of the Corrugated Pipe with Magnetic Targets Inclinometer Settlement System include:

- Dam settlement monitoring,
- Construction control of embankments and tills,

- Preload consolidation monitoring, and
- Subsidence monitoring.

However, the system may be used wherever measurement of displacement along a pipe is desired.

2 SAFETY

WARNING: USED WHEN AN OPERATING PROCEDURE OR PRACTICE, IF NOT CORRECTLY FOLLOWED, COULD RESULT IN PERSONAL INJURY OR LOSS OF LIFE.

CAUTION: USED WHEN AN OPERATING PROCEDURE OR PRACTICE, IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE TO OR DESTRUCTION OF EQUIPMENT.

CHECK: USED TO REMIND TECHNOLOGIST ABOUT QUALITY-RELATED FEATURES

NOTE: USED TO HIGHLIGHT SPECIFIC NON-SAFETY RELATED INFORMATION.

3 INSTALLATION

The following procedure is a suggested installation method. Site conditions and equipment may dictate alternative installation methods.

3.1 INSTALLING THE CORRUGATED PIPE

1. Ensure the corrugated pipe's end cap weight is securely attached to the bottom end of the corrugated pipe. The end cap weight is used to counter buoyancy in a wet borehole during installation.
2. A PE water pipe will have been factory installed inside the full length of the corrugated pipe.
3. Attach a grout hose to the bottom of the corrugated pipe with cable ties or wire.
4. Attach a wire rope choker to the opposite end of the corrugated pipe.
5. Lower the corrugated pipe into the borehole (or steel casing, if using). Once the corrugated pipe reaches the water table level, it will become buoyant. At this point, connect the water pipe to the water pump and begin to pump water into the corrugated pipe until it descends to the bottom of the borehole.

6 Pull on the corrugated pipe with a wire rope choker to maintain tension in the borehole.

NOTE: KEEPING THE CORRUGATED PIPE STRAIGHT BY PULLING ON IT WITH A WIRE ROPE CHOKER WILL FACILITATE SMOOTH INSTALLATION OF THE INCLINOMETER CASING.

7 Pull the centre water pipeline out of the corrugated pipe.

8 Sound the corrugated pipe to ensure it is clear.

9 Continue to fill the corrugated pipe with water using the water until the water reaches the top of the corrugated pipe.

10 Flush the grout line with water until the water returns to the top of the borehole.

3.2 INSTALLING THE INCLINOMETER CASING

1 Ensure the bottom cap is installed on the first section of the inclinometer casing.

2 Lower the inclinometer casing into the corrugated pipe, maintaining the correct groove azimuth.

3 Hold the inclinometer casing at the top and fill the inclinometer casing with clean water as each section is lowered. This will help to counter buoyancy during the installation.

4 Lower, attach, and fill sections until the inclinometer casing reaches the bottom of the corrugated pipe.

5 Completely fill the inclinometer casing with clean water and attach the top cap.

6 Secure the inclinometer casing to the top of the corrugated pipe with duct tape. Cut off the wire rope choker.

3.3 GROUTING THE BOREHOLE

1 Begin pumping the grout through the grout hose, grouting the borehole from the bottom to the top. Take care to ensure there are no lumps in the grout. The grout should be a cement bentonite.

CAUTION: ENSURE THERE ARE NO LUMPS IN THE GROUT PRIOR TO COMMENCING BACKFILL.

2 Pull casing (if using) up a few meters at a time as the borehole is backfilled. This will prevent the collapse of the borehole and help to bond the corrugated pipe to the borehole securely and cleanly. Keep the space between the inclinometer casing and the corrugated pipe free from grout and other obstructions.

CAUTION: ENSURE THE SPACE BETWEEN THE CORRUGATED PIPE AND THE INCLINOMETER CASING IS KEPT FREE FROM GROUT.

3 Continue to backfill the borehole with grout until the grout reaches the borehole collar.

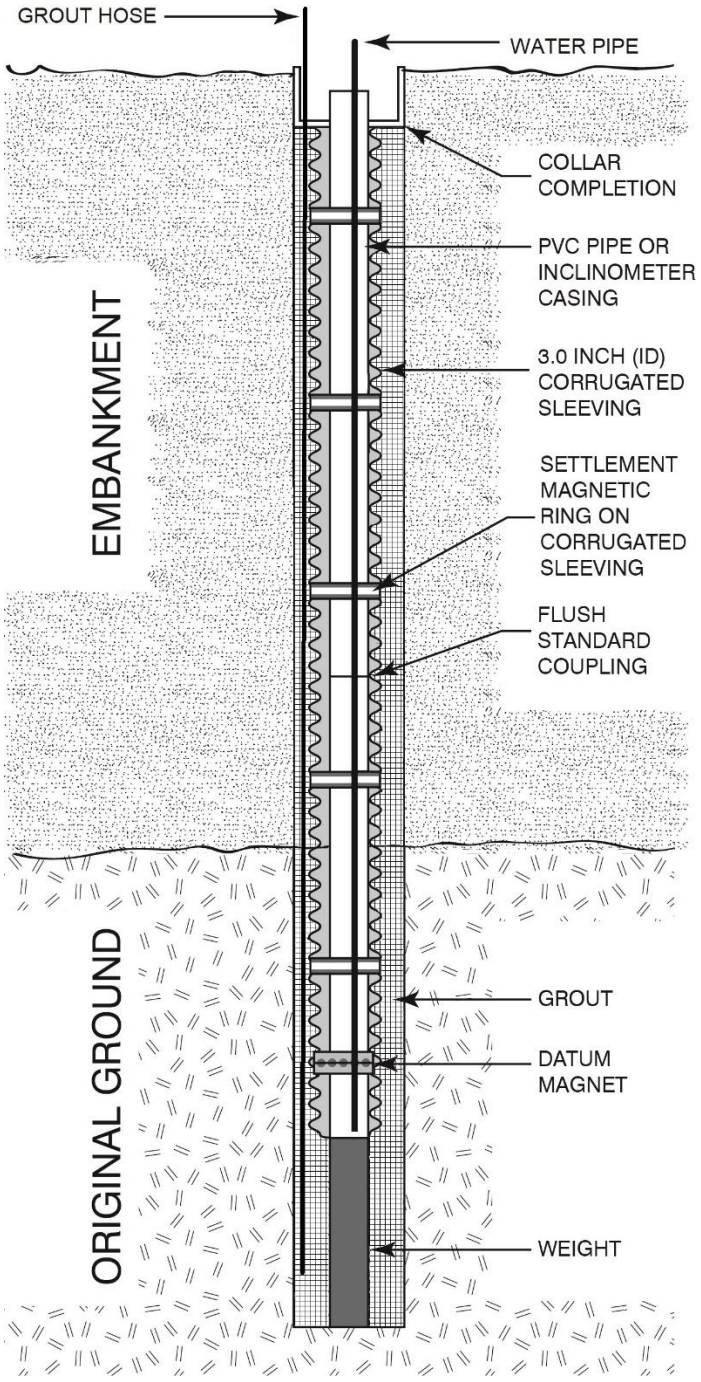

FIGURE 3-1 CORRUGATED PIPE WITH GROUT HOSE AND WATER PIPE

4 REED SWITCH PROBE

RST Reed Switch Probes are designed to measure the elevations of ring magnets in determining settlement. The RST Reed Switch Probe employs a high accuracy, NBS traceable, Teflon or polyethylene coated, non-stretch, flat tape, permanently marked in 1/100 ft. and/or 1 mm graduations.

The model 4001 reed switch probe is fully featured with a stainless-steel probe, light, buzzer, test switch and on/off sensitivity control. The moisture resistant electronics and standard 9-volt battery are housed in the reel hub. To replace the battery gently pull and twist the reel hub to remove. The hub assembly simply snaps into the cavity.

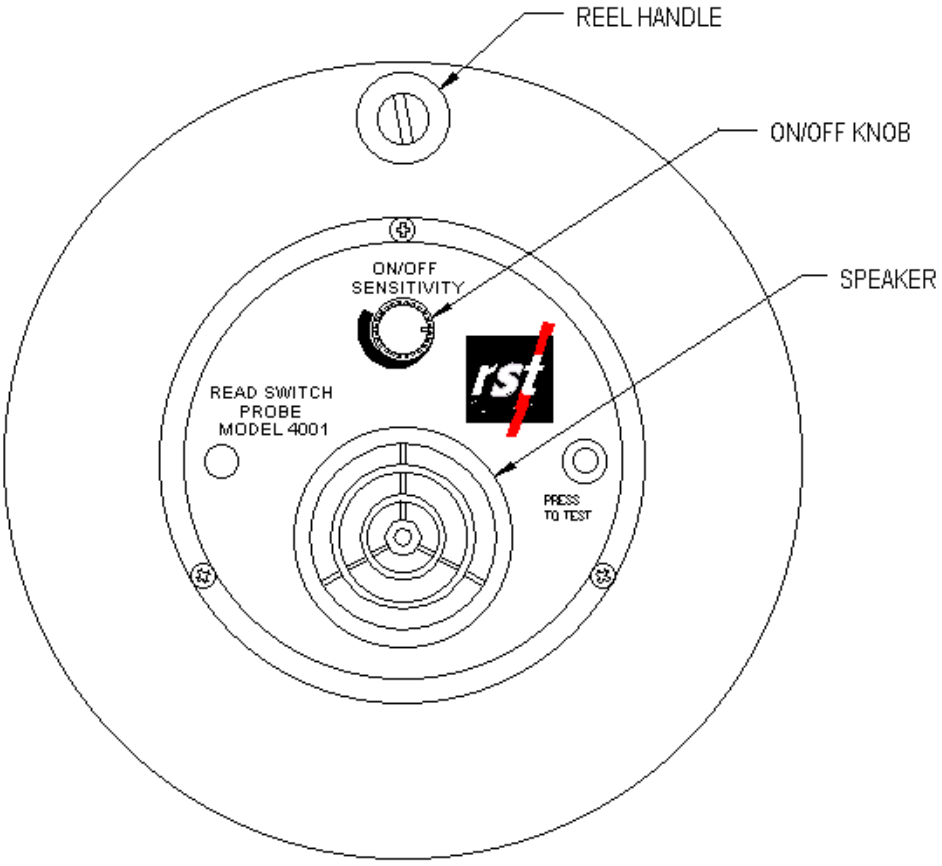

FIGURE 4-1 REED SWITCH PROBE CONTROLS

5 CALCULATION OF SETTLEMENT

Settlement is essentially the difference between the initial position of a target and the target's current position (with respect to the datum, or another fixed reference point).

5.1 INITIAL READINGS

The accuracy of the entire system relies heavily on the initial readings taken after installation. These readings should be taken with great care. It is strongly recommended that a minimum of three individual sets of readings be taken from three separate passes through the access pipe. The initial reference reading is an average of the readings for each target magnet. Subsequent readings are determined as a difference between the current and initial readings (i.e. the positions of target magnets). A positive value would indicate settlement and a negative value would indicate heave (or whichever sign convention is preferred).

5.2 TAKING READINGS

The following steps outline the procedure for taking readings:

1. Switch the probe on by turning the ON/OFF knob.

2. Lower the probe to the bottom of the inclinometer casing.

3. Raise the probe until the buzzer sounds. The position of the target (its depth) is found by reading directly off the measuring tape. Measurements are usually taken at the collar of the access pipe.

4. Record the depth of the target magnet on the field data sheet. Raise the probe up to the next target and repeat Step 3 for each target in the monitoring system. The depth for each target should always be determined by the first sound of the buzzer.

5.3 DATA REDUCTION

If a datum magnet is installed in stable soil or rock at the base of the borehole, changes in the position of the target magnets are referenced to this datum. Suppose a settlement system consists of 6 target magnets and a datum magnet, which are read on a monthly basis from January to March (Table 5-1). Depths are measured by reading from the tape in the location where it meets the collar of the access pipe.

TABLE 5-1 FIELD DATA REFERENCE TO THE TOP OF THE PIPE

Target Magnet	January (initial readings) (ft)	February (ft)	March (ft)
1	5.45	5.42	5.38
2	10.47	10.44	10.40
3	15.48	15.43	15.38
4	20.49	20.45	20.39
5	25.51	25.47	25.40
6	30.53	30.47	30.40
Datum Magnet	35.54	35.46	35.39

Settlement/heave is determined by taking the difference between the datum magnet (which is assumed to be stable) and the target magnet. For Target Magnet 1, the datum-referenced reading is:

$$35.54\ ft - 5.45\ ft = \mathbf{30.09\ ft}$$

Therefore, this target magnet is located 30.09 ft above the datum magnet. Table 5-2 lists the readings referenced to the datum magnet for each of the targets over the given monitoring period.

TABLE 5-2 FIELD DATA REFERENCE TO DATUM MAGNET

Target Magnet	January (initial readings) (ft)	February (ft)	March (ft)
1	30.09	30.04	30.01
2	25.07	25.02	24.99
3	20.06	20.03	20.01
4	15.05	15.01	15
5	10.03	9.99	9.99
6	5.01	4.99	4.99

A summary of the data is given in Table 5-3, which includes the initial readings, the measured readings, and the change in target position (Δd).

TABLE 5-3 DATA SUMMARY

Target Magnet	January (initial readings) (ft)	February reading (ft)	February Δd	March reading (ft)	March Δd
1	30.09	30.04	0.05	30.01	0.08
2	25.07	25.03	0.04	24.99	0.08
3	20.06	20.03	0.03	20.01	0.05
4	15.05	15.01	0.04	15	0.05
5	10.03	9.99	0.04	9.99	0.04
6	5.01	4.99	0.02	4.99	0.02

The Δd values given in Table 5-3 represent the difference between the initial and current position of the target magnets. In this case, positive values indicate settlement. Negative values indicate heave in the soil or structure being monitored.

The above example of settlement is related to a case where the access pipe is anchored in stable ground.

If the bottom of the access pipe is not anchored in stable ground, a datum target cannot be used as a reference point. The settlement should therefore be calculated with reference to the collar of the pipe, which must be surveyed before each set of readings is taken.

5.4 FREQUENCY OF READINGS

Frequency of measurements are site specific and should be determined by the project engineer, taking relevant project information into account.